WBS DICTIONARY FOR THE NOvA PROJECT
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The NOvA Work Breakdown Structure (WBS) defines the total set of items to be developed and produced in order to accomplish the scientific goals of the project.

WBS	Activity Description	WBS Definition
1	Research and Development	This summary level task is the work for the research and development of the Accelerator and NuMI Upgrades, the Nova Near and Far Detectors, and the Far Detector Hall.
1.0	ANU Planning, Engineering & Design	This Level 2 element covers the necessary removal of elements and the overall design and planning and needed for the accelerator and NuMI upgrades.
1.0.1	Recycler Upgrades	This summary task for the work to convert the Recycler Ring from an anti-proton storage ring to a proton pre-injector, includes planning for removing anti-proton specific devices in the Recycler, design of new injection and extraction lines, design of new injection, extraction, and abort kickers, design of a new 53 MHz RF system, and engineering to upgrade the instrumentation.
1.0.2	Main Injector Upgrades	This summary task covers the modifications to low level RF systems and associated machine timing modifications. It also includes planning for and removal of existing magnets and cavities no longer required. It also covers engineering for upgrades to existing LCW and RF cooling systems. Also included is the engineering and design for two extra MI RF stations.
1.0.3	NuMI Upgrades	This summary task covers the design and planning for modifications to NuMI Beamline to support 700kW NOvA operation in the medium energy neutrino beam configuration. It includes the primary beam upgrades to support a higher beam cycle time, upgrades to the cooling systems throughout the beamline for the increases power, and electrical infrastructure to support the additional power needs. Also included is the planning, engineering and design for a medium energy target, baffle and carrier and an upgraded hadron monitor. Planning for how the horn 2 will be moved to the medium energy position and the design of the stripline to connect to it in the new position are included.
1.0.4	Beam Physics	This summary task is to evaluate the efficacy of Proton Plan upgrades as applied to the ANU project, to perform preparative beam physics measurements, calculations, and simulations of the eventual ANU operation, and to establish and maintain a method of extrapolation to estimate future ANU proton production.
1.0.5	Project Management	This WBS details the management and administrative resources required by ANU during FY07. It includes labor for PM, deputy PM, L3, L4 mgrs, project engineers, ESH professional.

1.1	Site and Building	This level 2 element covers the design, planning, and value engineering for the Far Detector Hall as well as the site evaluation and environmental assessment.
1.1.1	Site Conditions Investigation	Site Conditions Investigation consists of the tasks required to provide a comprehensive understanding of the site conditions.
1.1.2	Title 1 Preparation	Document Development continues the development of the conceptual design and includes selecting and integrating building systems and materials, developing installation details focused on constructability, and describing the details with technically precise drawings and specifications.
1.1.3	(Retired)	Logistics is the process of planning, implementing and controlling the support functions of the project site during the construction phase including site utilities, maintenance, safeguards and security. The R&D Phase will investigate the requirements for the site logistics
1.1.4	Management - R&D Phase	Management for the R&D phase includes oversight of associated tasks as well as studies and investigations to verify choices or options

1.2	Liquid Scintillator R&D	This level 2 summary element coverst he developmetn and documentation of the specifications for the liquid scintillator required for both the enar and far detectors. This includes the studies, simulations, and measurements required to define these elements.
1.2.1	Requirements	Requirements document detailing experiment requirements on the liquid scintillator
1.2.2	Scintillator Composition Studies	Studies of light yield as a function of pseudocumene content;studies of light yield as a function of fluor (PPO, POPOP, bis-MSB) content; simulations of requirements on mineral oil attenuation length; measurements of mineral oil attenuation length; studies of light yield in an a-cell; studies of light yield in a test extrusion cells with scintillator mixed with mineral oil of varying attenuation lengths
1.2.3	Accelerated Aging Studies	Studies of the effect of pseudocumene content on fiber; studies of the effect of pseudocumene content on PVC; studies of the effect of pseudocumene content on glue joints
1.2.4	Scintillator Production Method Studies	Development of plan for scintillator production at Fermilab: (a) production of complete scintillator with premixed fluors (Eljen or Bicron) + mineral oil - mixing fluor mix with mineral oil, (b) production of complete scintillator from mineral oil, psuedocumene, & waveshifters - mixing waveshifters and pseudocumene - mixing fluor mix with mineral oil
1.2.5	Development of QC Methods	Develop reliable, accurate QC testing procedures for mineral oil arriving at mixing facility; develop reliable, accurate QC testing procedures for pseudocumene arriving at mixing facility; develop reliable, accurate QC testing procedures for testing mixed scintillator light yield at the mixing facility; develop reliable, accurate QC testing procedures for testing mixed scintillator light yield at the far detector site
1.2.6	Scintillator Transportation Studies	Delivering: mineral oil to Fermilab production facility by truck or rail delivering: (a) premix from Eljen or Bicron to the Fermilab production facility, or (b) fluors by commercial shipper and pseudocumene by truck or rail to the Fermilab production facility delivering: mixed scintillator 'just-in-time' to (a) near detector by truck , (b) far detector by rail or truck if optimum procedure is to deliver scintillator by rail to far detector, delivery of mixed scintillator from rail head to experiment specifications: (a) for heated tankers (truck or rail) for mineral oil and mixed scintillator, (b) for heated ISO tankers
1.2.7	Blending Investigations	Bicron (Saint-Gobain) for mixed scintillator -- can they produce enough materail to our specs? Q/C? Eljen or Bicron for premix -- can they make it to our specs? How will they handle Q/C on quantities they have probably not dealt with Mineral oil for premix or homebrew -- Penrico, Sonneborne, ... -- RFP already released Pseudocumene for homebrew -- RFP in draft form PPO, POPOP, bis-MSB form Curtisslab or European vendor -- RFP to be released
1.2.8	Component Aquisition Investigations	Investigate the options available for acquiring the various components required to blend liquid scintillator.
1.2.9	Integration Prototype Detector Scintillator Production	Delivery of scintillator components to Fermilab production facility production of mixed scintillator - fluors + mineral oil, or - waveshifters, pseudocumene, mineral oil delivery of mixed scintillator to the integration prototype near detector
1.2.10	Production Scintillator Specifications	Technical specification document for procurement of production quantities of liquid scintillator
1.2.11	Management - R&D Phase	Subproject management activties for the liquid scintillator R&D phase

1.3	Wave-Length-Shifting Fiber R&D	This level 2 summary element covers the development and documentation of the requirements for procurement, QA, storage, and shipping of the wavelength shifting fiber.
1.3.1	Requirements	Develop a document detailing the specifications for the wavelength shifting fiber.
1.3.2	Vendor Investigations	Develop, assess, and verify the ability of vendors to produce and QC wavelength shifting fiber to meet our specifications.
1.3.3	WLS Fiber Optimization Studies	Studies of wavelength shifting fiber to optimize the performance for our specific application.
1.3.4	Development of QA Methods	Develop methods and procedures for QA testing of the wavelength shifting fiber.
1.3.5	Integration Prototype Detector Fiber Production	Deliver and QA the fiber for the integration prototype near detector.
1.3.6	Production WLS Fiber Specifications	Produce the technical specification documents for procurement of production quantities of wavelength shifting fiber.
1.3.7	Management - R&D Phase	Subproject management activities for the WLS Fiber R&D phase

1.4	PVC Extrusion R&D	This level 2 summary element includes sutdies of various PVC materials and their properties, production of prototype extrusions, as well as the development and documentation of QA and shipping plans for the PVC extrusions.
1.4.1	Physical Properties Determination and Test Method Development	Measure optical and mechanical properties of extrusions and compare to NOvA specifications.
1.4.2	Raw Materials	Select PVC blend for prototype extrusion production.
1.4.3	Extrusions	Identify extruders capable of producing NOvA profiles. Select an extruder to produce prototype profiles. Develop methods for assuring the quality of extruded products, specifically the reflectivity and geometrical dimensions. Develop a shipping and handling plan for delivery of extrusions.
1.4.4	Shipping & Handling	Develop shipping and handling plan for delivery of extrusions.
1.4.5	Quality Assurance Hardware	Modify prototype QA hardware to be used for QA of preproduction extrusions.
1.4.6	Management - R&D Phase	Subproject management activities for the PVC extrusion R&D phase

1.5	PVC Module R&D	This level 2 summary element provides for develpoment and documentation of the procedures for assembly of the PVC modules and the design of the fiber manifolds, end seals, and the various machines and fixtures necessary for module construction. Development of QA and shipping plans is also included.
1.5.1	Requirements	Develop requirements documents for module assembly, manifolds, and end seals. QA requirements for the completed modules are also included.
1.5.2	End Seal R&D	Design and develop the manifolds and end seals as well as specification of QA procedures.
1.5.3	Photo Detector Interface R&D	Design and develop photodetector interface as well as specification of QA procedures.
1.5.4	Module Factory R&D	Develop assembly methods for the PVC modules as well as design of machines, tooling, and moving fixtures.
1.5.5	Quality Assurance and Quality Control Methods Development	Develop a QA plan for PVC module production. Consturction of required testing equipment is also included.
1.5.6	Module Shipping and Storage R&D	Develop plan for shipping and handling of extrusion modules between the module factory and the Detector sites and for managing the equipment necessary for shipping and handling.
1.5.7	Integration Prototype Detector (IPND) Modules	Produce the PVC modules for the integration prototype near detector.
1.5.8	Initial Production Module Specifications	Develop initial production module specifications.
1.5.9	Initial Factory Tooling Specifications	Develop initial factory tooling specifications.
1.5.10	Management - R&D Phase	Management tasks and budget for PVC module subproject during the R&D phase
1.5.11	Module Shipping and Storage R&D - Part 2	Develop plan for shipping and handling of extrusion modules between the module factory and the Detector sites and for managing the equipment necessary for shipping and handling.

1.6	Electronics R&D	This level 2 summary element includes the design, development, and testing of the front end electronics and infrastructure.
1.6.1	APD Modules	Development and procurement of prototype APD chips, APD carrier boards, TE coolers, optical connectors and the associated hardware that comprise the APD modules. Development of specifications for fiber alignment, power consumption, cooling, and QA are also included. APD modules for the Integration Prototype Near Detector are included here.
1.6.2	FEB	Design the front-end boards as well develop the testing and installation procedures. Front-end boards for the Integration Prototype Near Detector are included here.
1.6.3	Power Distribution	Design and specify the low voltage, high voltage, cooling, and power distribution fo rthe NOvA electronics. Power distribution for the Integration Prototype Near Detector is included here.
1.6.4	Management - R&D Phase	Management tasks and budget for Electronics subproject during the R&D phase.
1.6.5	Vertical Slice Tests	Create small-scale test facility for evaluating various configurations of prototype PVC extrusions, liquid scintillator, and WLS fiber using cosmic ray muons, APDs, and prototype versions of the front-end board.

1.7	DAQ System R&D	This summary level element incldues the development of specifications and design of the hardware and software necessary to acquire and record data to archival storage and to control and monitor both the Near and Far Detectors.
1.7.1	DAQ Software	Design and develop specifications for software to run on buffering/triggering hardware for archival of selected time frames and required online database
1.7.2	DAQ Hardware	Design and develop specifications for hardware for receiving signals from FEB, buffering and archival, delivery of clock/timing signals
1.7.3	Integration	Integration testing of DAQ and trigger electronics hardware and software. It assumes a single, central test facility and all test equipment, computers, and displays have been purchased in 1.7.1.
1.7.4	Detector Control System	Develop specifications and requirements for slow control system for Nova DAQ.
1.7.5	Management - R&D Phase	Management tasks and budget for DAQ subproject during the R&D phase.
1.7.6	Operate IPND	Resources required to operate the IPND in the MINOS Service Building.

1.8	Detector Assembly R&D	Perform R&D work to validate and optimize the mechanical designs and installation procedures for the NOvA Near and Far Detectors. This includes structural engineering calculations of the fully and partially assembled detectors, the mechanical design and prototyping of detector assembly mechanical systems and tooling, and the construction and testing of prototypes of both Near and Far Detectors. This task will select and document the baseline designs that will be used as the basis for the NOvA CDR and TDR.
1.8.1	Plane Assembly Adhesive R&D	The goal of this task is to choose an adhesive that is suitable for bonding extrusion modules together into 31-plane blocks for the far detector. The same adhesive will be used to construct the 7/8-plane segments for the near detector. This task is performed in close coordination with the determination of detector structural requirements (WBS 1.8.2) and design of the adhesive dispenser (under WBS 1.8.6). WBS 1.8.1 involves the specification of adhesive requirements, the development of adhesive test procedures, and the identification and testing of suitable adhesive candidates.
1.8.2	Structural Design and Validation	The goal of this task is to develop and optimize the structural design of the far detector, which is assembled from vertical planes of alternating horizontal and vertical extrusion modules and filled with liquid scintillator. This task involves the Finite Element Analyses (FEAs) of different candidate structures during assembly, before and after filling with liquid scintillator. The analysis will provide mechanical strength requirements for PVC extrusions, the adhesive that bonds them together and the bottom end seals on the vertical extrusion modules that support the weight of the detector. A series of small-scale and large-scale prototype structures will be constructed to check FEA predictions of the behavior of candidate structures. This task will be carried out in close coordination with the choice of adhesive (WBS 1.8.1) and the design of assembly fixtures (WBS 1.8.6). The large-scale prototype structures built under WBS 1.8.8 will provide a final validation of the structural analysis calculations performed under this task.
1.8.3	Liquid Scintillator Filling & Handling R&D	The goal of this task is to develop techniques and semi-automatic equipment for filling the near and far detector extrusion modules with liquid scintillator. This task provides specifications for the far detector liquid scintillator supply system, which is being built by WBS 2.1. It also makes use of the scintillator quality assurance equipment that is provided by WBS 2.2. The required rate of filling modules must be coordinated with both the scintillator production schedule of WBS 2.2 and the detector-filling rate specified by the far detector installation tasks, WBS 1.8.7 and 2.9.4.
1.8.4	Near Detector Assembly R&D	The goal of this task is to develop the procedures and for assembling the near detector. This includes specification of the near detector dimensions so that the components can be moved down the existing shaft and installed in the existing underground tunnel. This task includes the design of rigging equipment to move detector components into position and the moving system that allows it to be moved along the tunnel after it is filled with liquid scintillator. The task also includes the design of an assembly facility and associated procedures and equipment for assembling extrusion modules into 7/8-plane segments that can be moved underground. Finally, this task will design the steel-plate muon-catcher segment of the near detector, along with associated support structures and assembly equipment.

1.8.5	Integration Prototype Near Detector (IPND)	The goal of this task is to design, fabricate and install the Integration prototype Near Detector (IPND). The IPND will be structurally very similar to the Near Detector (ND) itself and it is likely that some components of the IPND will be reused for the ND, including the muon-catcher steel plates and perhaps some or all of the extrusion module segments. For this reason, IPND components will be designed so that they can be moved to the underground tunnel location of the ND. The IPND will be installed and operated at ground level in the MINOS Service Building, where it will be exposed to an off-axis beam of muon and electron neutrinos. It may also be moved to a charged particle test beam for further calibration at a later time. It is likely that the segment assembly facility for the IPND will be reused for the ND. The construction and installation schedule of the IPND will be closely coordinated with the suppliers of extrusion modules (WBS 2.5), readout hardware (WBS 2.6 and 2.7) and liquid scintillator (WBS 2.2). The schedule for construction and operation of the IPND will be coordinated with planning for the ND (WBS 2.8), because some IPND components will
1.8.6	Far Detector Assembly Engineering	The goal of this task is to specify and design the equipment needed to assemble and install the far detector. This includes cranes and other moving equipment required at the far detector site, as well as specialized equipment such as the block raiser and adhesive dispenser. This task will be closely coordinated with far detector installation planning (WBS 1.8.7), far detector prototype construction (WBS 1.8.8), as well as WBS 1.8.1, 1.8.2 and 1.8.3, which specify the adhesive requirements, detector structure, and liquid scintillator filling equipment.
1.8.7	Far Detector Installation Procedures	The goal of this task is to develop far detector installation procedures, schedules and labor requirements. This task is performed in close coordination with other WBS 1.8 far detector R&D tasks and with the Level 2 tasks that provide extrusion modules (WBS 2.5), readout hardware (WBS 2.6 and 2.7) and liquid scintillator (WBS 2.2). It must be very closely coordinated with the design of the far detector building and infrastructure by WBS 2.1. The far detector assembly must be accomplished as rapidly as possible in a cost effective, safe and environmentally responsible manner. This task will develop and evaluate the mechanical assembly quality assurance and safety protocols that will be used at the far detector site. The far detector prototype task, WBS 1.8.8, will provide valuable tests of the procedures, schedules and labor estimates developed under this task.
1.8.8	Far Detector Prototypes	The goal of this task is to test and optimize the procedures and equipment designs developed under other WBS 1.8 far detector tasks, by constructing full-size mechanical prototype structures of extrusion modules. The full-scale block-assembly prototype will test the installation procedures developed under WBS 1.8.7 and will perform time-and-motion studies of these procedures to allow the optimization of the installation schedule and its labor requirements. The full-height structural engineering prototype will provide a final check of structural engineering analyses relating to the mechanical stability of the detector in all stages of construction, before and after it is raised and filled with liquid scintillator. This task will lead to the final optimization of the designs of assembly tooling and materials handling equipment. It will culminate in the assembly, erection and testing of a full-size 31-plane block of the far detector under WBS 2.9.2.4, using the block raiser and other assembly equipment constructed for use at the far detector site.
1.8.9	Management - R&D Phase	Subproject management activities for the Detector Assembly R&D phase

1.9	Project Management - R&D	This level 2 summary element provides for internal project reviews, report preparation, site visits, local supervision, standards preparation, tracking and analysis, schedule preparation tracking and analysis, and change control. It also includes procurement of relevant software and computers, cost of running the project office, and the salaries of non-scientists working on the project.

2	Construction Project	WBS 2.0 is for the final design and construction of the NOvA Near and Far Detectors and the Far Detector Hall.
2.0	ANU Construction	This level 2 element includes the procurement, QA, construction, and installation of components necessary for accelerator improvements in the Main Injector and Recycler, as well as for upgrades to the beamline and target hall at the NuMI Facility.
2.0.1	Recycler Upgrades	This summary task for the work to convert the Recycler Ring from an anti-proton storage ring to a proton pre-injector, includes refurbishment of existing magnets, procurement and fabrication of new magnets, installation of injection, extraction, and RR-30 SS beamlines, procurement, fabrication, and installation of the new 53 MHz RF system, and procurement and fabrication of instrumentation upgrades.
2.0.1.1	Recycler Ring Modifications	This summary task covers procurement and fabrication for new and refurbishing of existing magnets for the Injection, Extraction, and RR-30 SS beamlines, as well as installation of the beamlines. It also includes procurement, fabrication and installation for the new 53 Mhz RF system. It also covers modifications to existing cooling systems.
2.0.1.2	Recycler Kicker System	This summary task covers procurement, fabrication, and installation for the five new kicker systems: RR Injection, Injection Gap Clearing, RR Extraction to MI, MI Injection, and RR Abort. This includes magnets, power supplies, and Fluorinert cooling systems for each of the 5 systems.
2.0.1.3	Recycler Instrumentation	This summary task covers the procurement, testing, and installation of upgrades to the existing Recycler BPM system, beam intensity monitors, and damper systems.

2.0.2	Main Injector Upgrades	This summary task covers the procurement and installation for upgrades to the existing vertical quad bus of MI. It also includes communication infrastructure for the 2 new service buildings. Also included is the procurement, fabrication, and installation of the 2 new RF stations, and the modifications to associated cooling systems.
2.0.2.1	MI Modifications	This summary task includes the procurement and installation of new transformer and modifications for MI vertical quad bus. It also covers procurement and installation of communications infrastructure for the 2 new service buildings at MI14 and MI39.
2.0.2.2	MI RF Cavities	This summary task covers procurement, fabrication, and installation for the 2 new MI RF stations.

2.0.3	NuMI Upgrades	This summary task covers the procurement, fabrication and installation of the modifications to the NuMI Beamline to support 700kW NOvA operation in the medium energy neutrino beam configuration. It includes the primary beam upgrades to support a higher beam cycle time, upgrades to the cooling systems throughout the beamline for the increases power, and electrical infrastructure to support the additional power needs. Also included is the medium energy target, baffle and carrier and an upgraded hadron monitor. Procurement, fabrication and installation of operations equipment in support of moving horn 2 and procurement, fabrication and assembly of the stripline, stripline block and chase temperature monitoring equipment are included also. Installation of the hadron monitor and target/carrier/baffle are included.
2.0.3.1	NuMI Primary Proton Beam	This summary task covers the procurement, engineering and technician efforts needed to upgrade the NuMI kicker power supply for increased pulsing repetition rate, to upgrade the 6 NuMI major dipole supplies, and to upgrade the NuMI primary bema profile monitors. It also includes the effort to replace the NuMI quads with the more robust, recovered quads from the A150 line and their power supplies.
2.0.3.2	NuMI Target Hall Technical Components	This summary task includes purchasing of a medium energy target and baffle from IHEP, purchase and construction of a target carrier and the assembly of all three of these pieces into a single unit ready which is then installed. This task also includes the purchasing of a hadron monitor from University of Texas, Austin and replacing the existing one in the tunnel.
2.0.3.3	NuMI Target Hall Infrastructure	This summary task covers the procurement, fabrication, and installation of operations equipment in the target hall for the NovA upgrades. It also includes procurement, fabrication, assembly and installation of the stripline extension and shielding blocks needed to support the movement of horn 2 to the medium energy location. Also included procurement, fabrication, installation, testing and troubleshooting of target chase cooling equipment and temperature monitoring equipment for the chase. Finally, it includes procurement, fabrication and assembly of new Horn 1 stripline cooling components. Installation of horn 1 and module and horn 2 and module are not on project, but operations tasks.
2.0.3.4	NuMI Decay Pipe/Hadron Absorber/Utilities	This task includes the procurement, installation, and start-up for all cooling system modifications for the NuMI cooling systems (RAW and non-RAW) for NOvA operation. It also includes the procurement, installation, and testing of Electrical Infrastructure equipment related to all RAW and Non-RAW Cooling System Modifications.

2.0.4	Project Management	This WBS details the management and administrative resources required by ANU during FY08-FY12. It includes administrative costs such as travel, computers, training, labor for reviews. It includes labor for PM, deputy PM, L3, L4 mgrs, project engineers, ESH professional.

2.1	Site and Building	This level 2 summary element covers the design and construction of the Site Preparation Package and the Far Detector Building
2.1.1	Site Preparation Package	Design and construction of the access road and site preparation work; perform wetlands mitigation in preparation for construction of the Far Detector Building.
2.1.2	Far Detector Building	Design, construction, and outfitting of the Far Detector Building in northern Minnesota. The building includes the detector enclosure, assembly area, and service building, as well as utilities and safety systems.
2.1.3	Site and Building Security	Design, procure, and install security systems for the Far Detector site and building.
2.1.4	Management	Support and management of WBS 2.1 activities includign quality assurance, value engineering, risk management, ES&H, monitoring of vendor performance and schedule, preparation of reports, and related activities.

2.2	Liquid Scintillator	This level 2 summary element covers the procurement, production, QA and shipping of the 3.2 million gallons of liquid scintillator required by the project for both the Near and Far Detectors.
2.2.1	Mineral Oil	Vendor selection, procurement, transport, and QA of mineral oil required for the liquid scintillator.
2.2.2	Pseudocumene	Vendor selection, procurement, transport, and QA of pseudocumene required for the liquid scintillator.
2.2.3	Waveshifters and Stadis 425	Vendor selection, procurement, transport, and QA of waveshifters required for the liquid scintillator as well as for procurement of the anti-static agent Stadis 425.
2.2.4	Blending	Select a vendor to blend the liquid scintillator, including blending and QA of the fluor concentrate, blending of the fluor concentrate with the mineral oil, and QA of the final scintillator blend.
2.2.5	Transport	Provide truck transport of the blended liquid scintillator from the blending facility to the Near and Far Detector sites.
2.2.6	Management - Construction Phase	This WBS includes the tasks required to support and manage WBS 2.2 activities including quality assurance, value management, risk management, monitoring of vendor performance and schedule, preparation of reports and other related activities.

2.3	Wave-Length-Shifting Fiber	This level 2 summary element covers the procurement, QA and shipping of the 13,000 km of wavelength shifting fiber required by the project.
2.3.1	Procurement	This WBS provides for producing a list of acceptable vendors after reviewing vendor R&D performance, preparation of RFPs, evaluation of vendor proposals and selection of vendors.
2.3.2	Production	This WBS provides for production of fiber QA testing equipment as well as the development of procedures, documentation and reporting requirements. Delivery of fiber spools to the module factories on a schedule consistent with factory schedules and available storage must also be organized and managed.
2.3.3	Management - Construction Phase	This WBS includes the tasks required to support and manage WBS 2.3 activities including quality assurance, value management, risk management, monitoring of vendor performance and schedule, preparation of reports and other related activities.

2.4	PVC Extrusions	This level 2 summary element covers the procurement, QA and shipping of PVC extrusions required by the project.
2.4.1	Procurement	This WBS element includes developing a list of vendors capable of producing the NOvA PVC compound and extruders capable of producing the NOvA profiles. Preparation of RFPs, evaluation of vendor proposals and selection of vendors is also included.
2.4.2	Extrusion Pre-Production	This WBS element includes the fabrication of dies, tooling and other hardware needed for the pre-production and production. Pre-production extrusions will be evaluated for adherence to mechanical tolerance, mechanical strength and reflectivity. Quality assurance methods for use in production and handiling procedures will be finalized. Pre-production extrusions will be provided to module assembly factories.
2.4.3	Extrusion Production	This WBS element provides for supervision and quality assurance monitoring of PVC extrusions.
2.4.4	Production Quality Assurance and Extrusion Evaluation	Procure and set up hardware for performing QA on the PVC extrusions as well as the necessary manpower.
2.4.5	Shipping & Handling	This WBS provides for the development and execution of a shipping and handling plan for delivering extrusions to module factories, for supervising trucking schedules and for managing the equipment necessary for shipping and handling.
2.4.6	Management - Construction Phase	This WBS includes the tasks required to support and manage WBS 2.4 activities including quality assurance, value management, risk management, monitoring of vendor performance and schedule, preparation of reports and other related activities.

2.5	PVC Modules	This level 2 summary element provides for construction and QA of the ~24,000 Far Detector PVC modules and ~400 Near Detector PVC Modules at the module factories and shipping of the completed and tested modules to their respective detector sites.
2.5.1	End Seals	Produce the fiber manifolds that cover and seal the readout end of a PVC module and route the WLS fibers to the photodetector interface, and produce the bottom plates that seal the other end of the PVC modules.
2.5.2	Optical Connector Production	Final design, procure, and QA the hardware necessary to connect the WLS fibers from the PVC modules to the APD modules.
2.5.3	Module Production	Set up and operate the module factory where sets of 16-cell PVC extrusions are glued into 32-cell objects, WLS fibers are inserted into each cell, the end seals are blued to the ends of the extrusions, and the WLS fibers are potted into the optical connector. QA of the completed modules as well as the procurement and construction of various machines necessary to assemble and test the modules is also included, along with transport of the completed modules to the Near and Far Detector sites.
2.5.4	Management - Construction Phase	This WBS element includes the tasks required to support and manage WBS 2.5 activities including quality assurance, value management, risk management, monitoring of factory performance and schedule, preparation of reports and other related activities.

2.6	Electronics Production	This level 2 summary element includes procurement of the Avalanche Photo Diode (APD) optical sensors, the thermo-electric (TE) coolers for cooling the APDs, the custom ASIC that amplifies and mutiplexes the APD signals, the ADC that digitizes the signals, and the FPGAs that zero suppress and time-stamps the data. The low-voltage system for the TE coolers and the front-end electornics, the high voltage ssytem for the APDs, and a cooling system to remove the heat from the TE coolers are included, as well as system design, board layout, and assembly and component testing.
2.6.1	APD Module Production	Procurement and QA of the APD chips, the APD carrier boards, the TE coolers, and the APD housing hardware. This task includes managing the flow of components for assembly and development and execution of the QA plan.
2.6.2	Readout - FEB	Delivery of the specified system to receive signals from the APD modules, digitize them, and deliver them to the DAQ system. This task includes managing the flow of components for assembly and development and execution of the QA plan.
2.6.3	Readout Infrastructure	Design, production, and installation of the infrastructure required to deliver power and cooling to operate the FEBs and APDs.
2.6.4	Management - Construction Phase	This WBS element includes the tasks required to support and manage WBS 2.6 activities including quality assurance, value management, risk management, monitoring of performance and schedule, preparation of reports and other related activities.

2.7	Data Acquisition System	This level 2 summary element includes the hardware and software to record the data to archival storage and to control and monitor both the Near and Far Detectors. It includes the fiber, cable, switches, and memory necessary to move and buffer the data, a PC farm for inline filtering, local disk storage, a system for moving data to permanent storage at Fermilab, software, and testing.
2.7.1	DAQ Software	Produce and test software to run on buffering/triggering hardware for archival of selected time frames and required online database.
2.7.2	DAQ Hardware	Design, QA, and install hardware for receiving signals from FEB, buffering and archival, delivery of clock/timing signals.
2.7.3	Integration	Integration testing of DAQ and trigger electronics hardware and software.
2.7.4	Detector Control System	Controls required to receive and archive monitoring data as needed.
2.7.5	Management - Construction Phase	This WBS element includes the tasks required to support and manage WBS 2.7 activities including quality assurance, value management, risk management, monitoring of performance and schedule, preparation of reports and other related activities.

2.8	Near Detector Assembly	This level 2 element provides for site preparation of the region to contain the Near Detector, mechanical assembly and installation of the detector itself, assembly of a liquid scintillator filling system extending from the MINOS service building to underground plus utilization of this system, and finally oversight of the outfitting of the detector to ready it for doing physics. The site preparation consists of the repositioning of considerable MINOS cabling and infrastructure, and the construction, once the repositioning is compete, of a new cavern at the appropriate off axis angle. The constrution of the detector involves the steel and PVC modules of the muon catcher, three blocks recycled from the IPND and three new blocks.
2.8.1	Near Detector Site Preparation	Complete the engineering design, procurement, and fabrication and installation of the utilities and infrastructure required to install and operate the Near Detector in its underground tunnel location. These systems include excavation, lighting, HVAC, electrical power, fire protection, chilled water, and liquid scintillator containment. Also included are technical and ES&H reviews and approvals of equipment and assembly procedures.
2.8.2	Mechanical Construction and Installation	Complete the engineering design, procurement, and fabrication of the Near Detector muon steel segment, the detector support structure, and the systems for moving the detctor subassemblies underground and to different positions along the MINOS access tunnel. Also included are any shipping and moving costs and the final optimization, review, and approval of equipment and assembly procedures.
2.8.3	Liquid Scintillator Filling Equipment	Complete the engineering design, procurement, and fabrication of the Near Detector liquid scintillator supply system, the filling machine, and the plumbing that connects these together and to the detector modules. Secondary containment of the liquid scintillator is included as well as any shipping and moving costs and the final optimization, review, and approval of equipment and assembly procedures.
2.8.4	Installation Coordination	Install readout electronics, cabling, plumbing, filling with liquid scintillator, final component QA tests, detector alignment, the implemetation of safety systems, the review and approval of equipment and installation procedures, and the documentation and intial commissioning of the assembled detector and its moving system.
2.8.5	Management - Construction Phase	This WBS element includes the tasks required to support and manage WBS 2.8 activities including quality assurance, value management, risk management, schedule monitoring, preparation of reports and other related activities.

2.9	Far Detector Assembly	This task provides for the engineering design of the mechanical systems and tooling needed to install the NOvA Far Detector. Fabrication of the necessary tooling, installation and commissioning of the detector in the detector building in northern Minnesota is also included. This task requires close coordination with the WBS 2.1 (far site and buildings), WBS 2.2 (scintillator), WBS 2.5 (PVC modules), and WBS 2.6/2.7 (electronics and DAQ).
2.9.1	Mechanical Systems	Complete the engineering design, procurement and fabrication of the Far Detector mechanical support structures and other block assembly equipment, including the block pivoter, block safety contraint beam, module lifting fixtures, adhesive dispenser, and survey equipment. This task includes final optimization, review and approval of associated equipment and assembly procedures.
2.9.2	Detector Infrastructure	Install infrastructure necessary to support detector construction, including electrical infrastructure for detector assembly and scintillator filling equipment and design and fabrication of the north and south bookends. This also includes engineering design, procurement, and fabrication of the block raiser, the 31-plane block assembly fixtures, the adhesive dispensing system, and the detector alignment systems. It also incluedes any shipping and moving costs and the final optimization, review, and approval of associated equipment and assembly procedures.
2.9.3	Scintillator Filling Equipment	Complete the engineering design, the procurement and fabrication of the Far Detector liquid scintillator transfer and filling equipment, the associated distribution controls, the distribution plumbing that connects the transfer equipment to the filling machines and detector modules and the vapor recovery system.
2.9.4	Block Assembly and Installation	Design and construction of the block pivoter, procurement and installation of the adhesive dispenser, esign and procurement of the block pallets that form the base of each block, procuremetn of the adhesive required for block assembly, and the scintillator expansion tanks required prior to filling the assembled blocks with liquid scintillator. It also includes the assembly and erection of blocks, installation of readout electronics, cabling and plumbing, filling the blocks with liquid scintillator, final component QA tests, detector alignment, the implementation of safety systems, the review and approval of equipment and installation procedures, and the documentation and initial commissioning of the assembled detector.
2.9.5	Management - Construction Phase	This WBS element includes the tasks required to support and manage WBS 2.9 activities including quality assurance, value management, risk management, schedule monitoring, preparation of reports and other related activities.

2.10	Project Management - Construction	This Level 2 summary element consists of reviews, reports, site visits, local supervision, running technical board meetings, standards preparation, tracking and analysis, schedule preparation tracking and analysis, change control. It also includes procurement of relevant software and computers, the cost of running the project office and the salaries of non-scientists working in the project office.

NOVA PROJECT
WBS DICTIONARY

WBS	Activity Description	WBS Definition
1.0.1	Recycler Upgrades	This summary task for the work to convert the Recycler Ring from an anti-proton storage ring to a proton pre-injector, includes planning for removing anti-proton specific devices in the Recycler, design of new injection and extraction lines, design of new injection, extraction, and abort kickers, design of a new 53 MHz RF system, and engineering to upgrade the instrumentation.
2.0.1	Recycler Upgrades	This summary task for the work to convert the Recycler Ring from an anti-proton storage ring to a proton pre-injector, includes refurbishment of existing magnets, procurement and fabrication of new magnets, installation of injection, extraction, and RR-30 SS beamlines, procurement, fabrication, and installation of the new 53 MHz RF system, and procurement and fabrication of instrumentation upgrades.
2.0.1.1	Recycler Ring Modifications	This summary task covers procurement and fabrication for new and refurbishing of existing magnets for the Injection, Extraction, and RR-30 SS beamlines, as well as installation of the beamlines. It also includes procurement, fabrication and installation for the new 53 Mhz RF system. It also covers modifications to existing cooling systems.
2.0.1.2	Recycler Kicker System	This summary task covers procurement, fabrication, and installation for the five new kicker systems: RR Injection, Injection Gap Clearing, RR Extraction to MI, MI Injection, and RR Abort. This includes magnets, power supplies, and Fluorinert cooling systems for each of the 5 systems.
2.0.1.3	Recycler Instrumentation	This summary task covers the procurement, testing, and installation of upgrades to the existing Recycler BPM system, beam intensity monitors, and damper systems.

NOVA PROJECT
WBS DICTIONARY

WBS	Activity Description	WBS Definition
1.0.2	Main Injector Upgrades	This summary task covers the modifications to low level RF systems and associated machine timing modifications. It also includes planning for and removal of existing magnets and cavities no longer required. It also covers engineering for upgrades to existing LCW and RF cooling systems. Also included is the engineering and design for two extra MI RF stations.
2.0.2	Main Injector Upgrades	This summary task covers the procurement and installation for upgrades to the existing vertical quad bus of MI. It also includes communication infrastructure for the 2 new service buildings. Also included is the procurement, fabrication, and installation of the 2 new RF stations, and the modifications to associated cooling systems.
2.0.2.1	MI Modifications	This summary task includes the procurement and installation of new transformer and modifications for MI vertical quad bus. It also covers procurement and installation of communications infrastructure for the 2 new service buildings at MI14 and MI39.
2.0.2.2	MI RF Cavities	This summary task covers procurement, fabrication, and installation for the 2 new MI RF stations.

NOVA PROJECT
WBS DICTIONARY

WBS	Activity Description	WBS Definition
1.0.3	NuMI Upgrades	This summary task covers the design and planning for modifications to NuMI Beamline to support 700kW NOvA operation in the medium energy neutrino beam configuration. It includes the primary beam upgrades to support a higher beam cycle time, upgrades to the cooling systems throughout the beamline for the increases power, and electrical infrastructure to support the additional power needs. Also included is the planning, engineering and design for a medium energy target, baffle and carrier and an upgraded hadron monitor. Planning for how the horn 2 will be moved to the medium energy position and the design of the stripline to connect to it in the new position are included.
2.0.3	NuMI Upgrades	This summary task covers the procurement, fabrication and installation of the modifications to the NuMI Beamline to support 700kW NOvA operation in the medium energy neutrino beam configuration. It includes the primary beam upgrades to support a higher beam cycle time, upgrades to the cooling systems throughout the beamline for the increases power, and electrical infrastructure to support the additional power needs. Also included is the medium energy target, baffle and carrier and an upgraded hadron monitor. Procurement, fabrication and installation of operations equipment in support of moving horn 2 and procurement, fabrication and assembly of the stripline, stripline block and chase temperature monitoring equipment are included also. Installation of the hadron monitor and target/carrier/baffle are included.
2.0.3.1	NuMI Primary Proton Beam	This summary task covers the procurement, engineering and technician efforts needed to upgrade the NuMI kicker power supply for increased pulsing repetition rate, to upgrade the 6 NuMI major dipole supplies, and to upgrade the NuMI primary bema profile monitors. It also includes the effort to replace the NuMI quads with the more robust, recovered quads from the A150 line and their power supplies.
2.0.3.2	NuMI Target Hall Technical Components	This summary task includes purchasing of a medium energy target and baffle from IHEP, purchase and construction of a target carrier and the assembly of all three of these pieces into a single unit ready which is then installed. This task also includes the purchasing of a hadron monitor from University of Texas, Austin and replacing the existing one in the tunnel.
2.0.3.3	NuMI Target Hall Infrastructure	This summary task covers the procurement, fabrication, and installation of operations equipment in the target hall for the NovA upgrades. It also includes procurement, fabrication, assembly and installation of the stripline extension and shielding blocks needed to support the movement of horn 2 to the medium energy location. Also included procurement, fabrication, installation, testing and troubleshooting of target chase cooling equipment and temperature monitoring equipment for the chase. Finally, it includes procurement, fabrication and assembly of new Horn 1 stripline cooling components. Installation of horn 1 and module and horn 2 and module are not on project, but operations tasks.
2.0.3.4	NuMI Decay Pipe/Hadron Absorber/Utilities	This task includes the procurement, installation, and start-up for all cooling system modifications for the NuMI cooling systems (RAW and non-RAW) for NOvA operation. It also includes the procurement, installation, and testing of Electrical Infrastructure equipment related to all RAW and Non-RAW Cooling System Modifications.

NOVA PROJECT
WBS DICTIONARY

WBS	Activity Description	WBS Definition
1.0.4	Beam Physics	This summary task is to evaluate the efficacy of Proton Plan upgrades as applied to the ANU project, to perform preparative beam physics measurements, calculations, and simulations of the eventual ANU operation, and to establish and maintain a method of extrapolation to estimate future ANU proton production.

NOVA PROJECT
WBS DICTIONARY

WBS	Activity Description	WBS Definition
1.0.5	Project Management	This WBS details the management and administrative resources required by ANU during FY07. It includes labor for PM, deputy PM, L3, L4 mgrs, project engineers, ESH professional.
2.0.4	Project Management	This WBS details the management and administrative resources required by ANU during FY08-FY12. It includes administrative costs such as travel, computers, training, labor for reviews. It includes labor for PM, deputy PM, L3, L4 mgrs, project engineers, ESH professional.

NOVA PROJECT
WBS DICTIONARY

WBS	Activity Description	WBS Definition
1.1	Site and Building	This level 2 element covers the design, planning, and value engineering for the Far Detector Hall as well as the site evaluation and environmental assessment.
1.1.1	Site Conditions Investigation	Site Conditions Investigation consists of the tasks required to provide a comprehensive understanding of the site conditions.
1.1.2	Title 1 Preparation	Document Development continues the development of the conceptual design and includes selecting and integrating building systems and materials, developing installation details focused on constructability, and describing the details with technically precise drawings and specifications.
1.1.3	(Retired)	Logistics is the process of planning, implementing and controlling the support functions of the project site during the construction phase including site utilities, maintenance, safeguards and security. The R&D Phase will investigate the requirements for the site logistics
1.1.4	Management - R&D Phase	Management for the R&D phase includes oversight of associated tasks as well as studies and investigations to verify choices or options
2.1	Site and Building	This level 2 summary element covers the design and construction of the Site Preparation Package and the Far Detector Building
2.1.1	Site Preparation Package	Design and construction of the access road and site preparation work; perform wetlands mitigation in preparation for construction of the Far Detector Building.
2.1.2	Far Detector Building	Design, construction, and outfitting of the Far Detector Building in northern Minnesota. The building includes the detector enclosure, assembly area, and service building, as well as utilities and safety systems.
2.1.3	Site and Building Security	Design, procure, and install security systems for the Far Detector site and building.
2.1.4	Management	Support and management of WBS 2.1 activities includign quality assurance, value engineering, risk management, ES&H, monitoring of vendor performance and schedule, preparation of reports, and related activities.

NOVA PROJECT
WBS DICTIONARY

WBS	Activity Description	WBS Definition
1.2	Liquid Scintillator R&D	This level 2 summary element coverst he developmetn and documentation of the specifications for the liquid scintillator required for both the enar and far detectors. This includes the studies, simulations, and measurements required to define these elements.
1.2.1	Requirements	Requirements document detailing experiment requirements on the liquid scintillator
1.2.2	Scintillator Composition Studies	Studies of light yield as a function of pseudocumene content;studies of light yield as a function of fluor (PPO, POPOP, bis-MSB) content; simulations of requirements on mineral oil attenuation length; measurements of mineral oil attenuation length; studies of light yield in an a-cell; studies of light yield in a test extrusion cells with scintillator mixed with mineral oil of varying attenuation lengths
1.2.3	Accelerated Aging Studies	Studies of the effect of pseudocumene content on fiber; studies of the effect of pseudocumene content on PVC; studies of the effect of pseudocumene content on glue joints
1.2.4	Scintillator Production Method Studies	Development of plan for scintillator production at Fermilab: (a) production of complete scintillator with premixed fluors (Eljen or Bicron) + mineral oil - mixing fluor mix with mineral oil, (b) production of complete scintillator from mineral oil, psuedocumene, & waveshifters - mixing waveshifters and pseudocumene - mixing fluor mix with mineral oil
1.2.5	Development of QC Methods	Develop reliable, accurate QC testing procedures for mineral oil arriving at mixing facility; develop reliable, accurate QC testing procedures for pseudocumene arriving at mixing facility; develop reliable, accurate QC testing procedures for testing mixed scintillator light yield at the mixing facility; develop reliable, accurate QC testing procedures for testing mixed scintillator light yield at the far detector site
1.2.6	Scintillator Transportation Studies	Delivering: mineral oil to Fermilab production facility by truck or rail delivering: (a) premix from Eljen or Bicron to the Fermilab production facility, or (b) fluors by commercial shipper and pseudocumene by truck or rail to the Fermilab production facility delivering: mixed scintillator 'just-in-time' to (a) near detector by truck , (b) far detector by rail or truck if optimum procedure is to deliver scintillator by rail to far detector, delivery of mixed scintillator from rail head to experiment specifications: (a) for heated tankers (truck or rail) for mineral oil and mixed scintillator, (b) for heated ISO tankers

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1.2.7	Blending Investigations	Bicron (Saint-Gobain) for mixed scintillator -- can they produce enough materail to our specs? Q/C? Eljen or Bicron for premix -- can they make it to our specs? How will they handle Q/C on quantities they have probably not dealt with Mineral oil for premix or homebrew -- Penrico, Sonneborne, ... -- RFP already released Pseudocumene for homebrew -- RFP in draft form PPO, POPOP, bis-MSB form Curtisslab or European vendor -- RFP to be released
1.2.8	Component Aquisition Investigations	Investigate the options available for acquiring the various components required to blend liquid scintillator.
1.2.9	Integration Prototype Detector Scintillator Production	Delivery of scintillator components to Fermilab production facility production of mixed scintillator - fluors + mineral oil, or - waveshifters, pseudocumene, mineral oil delivery of mixed scintillator to the integration prototype near detector
1.2.10	Production Scintillator Specifications	Technical specification document for procurement of production quantities of liquid scintillator
1.2.11	Management - R&D Phase	Subproject management activties for the liquid scintillator R&D phase
2.2	Liquid Scintillator	This level 2 summary element covers the procurement, production, QA and shipping of the 3.2 million gallons of liquid scintillator required by the project for both the Near and Far Detectors.
2.2.1	Mineral Oil	Vendor selection, procurement, transport, and QA of mineral oil required for the liquid scintillator.
2.2.2	Pseudocumene	Vendor selection, procurement, transport, and QA of pseudocumene required for the liquid scintillator.
2.2.3	Waveshifters and Stadis 425	Vendor selection, procurement, transport, and QA of waveshifters required for the liquid scintillator as well as for procurement of the anti-static agent Stadis 425.
2.2.4	Blending	Select a vendor to blend the liquid scintillator, including blending and QA of the fluor concentrate, blending of the fluor concentrate with the mineral oil, and QA of the final scintillator blend.
2.2.5	Transport	Provide truck transport of the blended liquid scintillator from the blending facility to the Near and Far Detector sites.
2.2.6	Management - Construction Phase	This WBS includes the tasks required to support and manage WBS 2.2 activities including quality assurance, value management, risk management, monitoring of vendor performance and schedule, preparation of reports and other related activities.

NOVA PROJECT
WBS DICTIONARY

WBS	Activity Description	WBS Definition
1.3	Wave-Length-Shifting Fiber R&D	This level 2 summary element covers the development and documentation of the requirements for procurement, QA, storage, and shipping of the wavelength shifting fiber.
1.3.1	Requirements	Develop a document detailing the specifications for the wavelength shifting fiber.
1.3.2	Vendor Investigations	Develop, assess, and verify the ability of vendors to produce and QC wavelength shifting fiber to meet our specifications.
1.3.3	WLS Fiber Optimization Studies	Studies of wavelength shifting fiber to optimize the performance for our specific application.
1.3.4	Development of QA Methods	Develop methods and procedures for QA testing of the wavelength shifting fiber.
1.3.5	Integration Prototype Detector Fiber Production	Deliver and QA the fiber for the integration prototype near detector.
1.3.6	Production WLS Fiber Specifications	Produce the technical specification documents for procurement of production quantities of wavelength shifting fiber.
1.3.7	Management - R&D Phase	Subproject management activities for the WLS Fiber R&D phase
2.3	Wave-Length-Shifting Fiber	This level 2 summary element covers the procurement, QA and shipping of the 13,000 km of wavelength shifting fiber required by the project.
2.3.1	Procurement	This WBS provides for producing a list of acceptable vendors after reviewing vendor R&D performance, preparation of RFPs, evaluation of vendor proposals and selection of vendors.
2.3.2	Production	This WBS provides for production of fiber QA testing equipment as well as the development of procedures, documentation and reporting requirements. Delivery of fiber spools to the module factories on a schedule consistent with factory schedules and available storage must also be organized and managed.
2.3.3	Management - Construction Phase	This WBS includes the tasks required to support and manage WBS 2.3 activities including quality assurance, value management, risk management, monitoring of vendor performance and schedule, preparation of reports and other related activities.

NOVA PROJECT
WBS DICTIONARY

WBS	Activity Description	WBS Definition
1.4	PVC Extrusion R&D	This level 2 summary element includes sutdies of various PVC materials and their properties, production of prototype extrusions, as well as the development and documentation of QA and shipping plans for the PVC extrusions.
1.4.1	Physical Properties Determination and Test Method Development	Measure optical and mechanical properties of extrusions and compare to NOvA specifications.
1.4.2	Raw Materials	Select PVC blend for prototype extrusion production.
1.4.3	Extrusions	Identify extruders capable of producing NOvA profiles. Select an extruder to produce prototype profiles. Develop methods for assuring the quality of extruded products, specifically the reflectivity and geometrical dimensions. Develop a shipping and handling plan for delivery of extrusions.
1.4.4	Shipping & Handling	Develop shipping and handling plan for delivery of extrusions.
1.4.5	Quality Assurance Hardware	Modify prototype QA hardware to be used for QA of preproduction extrusions.
1.4.6	Management - R&D Phase	Subproject management activities for the PVC extrusion R&D phase
2.4	PVC Extrusions	This level 2 summary element covers the procurement, QA and shipping of PVC extrusions required by the project.
2.4.1	Procurement	This WBS element includes developing a list of vendors capable of producing the NOvA PVC compound and extruders capable of producing the NOvA profiles. Preparation of RFPs, evaluation of vendor proposals and selection of vendors is also included.
2.4.2	Extrusion Pre-Production	This WBS element includes the fabrication of dies, tooling and other hardware needed for the pre-production and production. Pre-production extrusions will be evaluated for adherence to mechanical tolerance, mechanical strength and reflectivity. Quality assurance methods for use in production and handiling procedures will be finalized. Pre-production extrusions will be provided to module assembly factories.
2.4.3	Extrusion Production	This WBS element provides for supervision and quality assurance monitoring of PVC extrusions.
2.4.4	Production Quality Assurance and Extrusion Evaluation	Procure and set up hardware for performing QA on the PVC extrusions as well as the necessary manpower.
2.4.5	Shipping & Handling	This WBS provides for the development and execution of a shipping and handling plan for delivering extrusions to module factories, for supervising trucking schedules and for managing the equipment necessary for shipping and handling.
2.4.6	Management - Construction Phase	This WBS includes the tasks required to support and manage WBS 2.4 activities including quality assurance, value management, risk management, monitoring of vendor performance and schedule, preparation of reports and other related activities.

NOVA PROJECT
WBS DICTIONARY

WBS	Activity Description	WBS Definition
1.5	PVC Module R&D	This level 2 summary element provides for develpoment and documentation of the procedures for assembly of the PVC modules and the design of the fiber manifolds, end seals, and the various machines and fixtures necessary for module construction. Development of QA and shipping plans is also included.
1.5.1	Requirements	Develop requirements documents for module assembly, manifolds, and end seals. QA requirements for the completed modules are also included.
1.5.2	End Seal R&D	Design and develop the manifolds and end seals as well as specification of QA procedures.
1.5.3	Photo Detector Interface R&D	Design and develop photodetector interface as well as specification of QA procedures.
1.5.4	Module Factory R&D	Develop assembly methods for the PVC modules as well as design of machines, tooling, and moving fixtures.
1.5.5	Quality Assurance and Quality Control Methods Development	Develop a QA plan for PVC module production. Consturction of required testing equipment is also included.
1.5.6	Module Shipping and Storage R&D	Develop plan for shipping and handling of extrusion modules between the module factory and the Detector sites and for managing the equipment necessary for shipping and handling.
1.5.7	Integration Prototype Detector (IPND) Modules	Produce the PVC modules for the integration prototype near detector.
1.5.8	Initial Production Module Specifications	Develop initial production module specifications.
1.5.9	Initial Factory Tooling Specifications	Develop initial factory tooling specifications.
1.5.10	Management - R&D Phase	Management tasks and budget for PVC module subproject during the R&D phase
1.5.11	Module Shipping and Storage R&D - Part 2	Develop plan for shipping and handling of extrusion modules between the module factory and the Detector sites and for managing the equipment necessary for shipping and handling.
2.5	PVC Modules	This level 2 summary element provides for construction and QA of the ~24,000 Far Detector PVC modules and ~400 Near Detector PVC Modules at the module factories and shipping of the completed and tested modules to their respective detector sites.
2.5.1	End Seals	Produce the fiber manifolds that cover and seal the readout end of a PVC module and route the WLS fibers to the photodetector interface, and produce the bottom plates that seal the other end of the PVC modules.
2.5.2	Optical Connector Production	Final design, procure, and QA the hardware necessary to connect the WLS fibers from the PVC modules to the APD modules.
2.5.3	Module Production	Set up and operate the module factory where sets of 16-cell PVC extrusions are glued into 32-cell objects, WLS fibers are inserted into each cell, the end seals are blued to the ends of the extrusions, and the WLS fibers are potted into the optical connector. QA of the completed modules as well as the procurement and construction of various machines necessary to assemble and test the modules is also included, along with transport of the completed modules to the Near and Far Detector sites.
2.5.4	Management - Construction Phase	This WBS element includes the tasks required to support and manage WBS 2.5 activities including quality assurance, value management, risk management, monitoring of factory performance and schedule, preparation of reports and other related activities.

NOVA PROJECT
WBS DICTIONARY

WBS	Activity Description	WBS Definition
1.6	Electronics R&D	This level 2 summary element includes the design, development, and testing of the front end electronics and infrastructure.
1.6.1	APD Modules	Development and procurement of prototype APD chips, APD carrier boards, TE coolers, optical connectors and the associated hardware that comprise the APD modules. Development of specifications for fiber alignment, power consumption, cooling, and QA are also included. APD modules for the Integration Prototype Near Detector are included here.
1.6.2	FEB	Design the front-end boards as well develop the testing and installation procedures. Front-end boards for the Integration Prototype Near Detector are included here.
1.6.3	Power Distribution	Design and specify the low voltage, high voltage, cooling, and power distribution fo rthe NOvA electronics. Power distribution for the Integration Prototype Near Detector is included here.
1.6.4	Management - R&D Phase	Management tasks and budget for Electronics subproject during the R&D phase.
1.6.5	Vertical Slice Tests	Create small-scale test facility for evaluating various configurations of prototype PVC extrusions, liquid scintillator, and WLS fiber using cosmic ray muons, APDs, and prototype versions of the front-end board.
2.6	Electronics Production	This level 2 summary element includes procurement of the Avalanche Photo Diode (APD) optical sensors, the thermo-electric (TE) coolers for cooling the APDs, the custom ASIC that amplifies and mutiplexes the APD signals, the ADC that digitizes the signals, and the FPGAs that zero suppress and time-stamps the data. The low-voltage system for the TE coolers and the front-end electornics, the high voltage ssytem for the APDs, and a cooling system to remove the heat from the TE coolers are included, as well as system design, board layout, and assembly and component testing.
2.6.1	APD Module Production	Procurement and QA of the APD chips, the APD carrier boards, the TE coolers, and the APD housing hardware. This task includes managing the flow of components for assembly and development and execution of the QA plan.
2.6.2	Readout - FEB	Delivery of the specified system to receive signals from the APD modules, digitize them, and deliver them to the DAQ system. This task includes managing the flow of components for assembly and development and execution of the QA plan.
2.6.3	Readout Infrastructure	Design, production, and installation of the infrastructure required to deliver power and cooling to operate the FEBs and APDs.
2.6.4	Management - Construction Phase	This WBS element includes the tasks required to support and manage WBS 2.6 activities including quality assurance, value management, risk management, monitoring of performance and schedule, preparation of reports and other related activities.

NOVA PROJECT
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WBS	Activity Description	WBS Definition
1.7	DAQ System R&D	This summary level element incldues the development of specifications and design of the hardware and software necessary to acquire and record data to archival storage and to control and monitor both the Near and Far Detectors.
1.7.1	DAQ Software	Design and develop specifications for software to run on buffering/triggering hardware for archival of selected time frames and required online database
1.7.2	DAQ Hardware	Design and develop specifications for hardware for receiving signals from FEB, buffering and archival, delivery of clock/timing signals
1.7.3	Integration	Integration testing of DAQ and trigger electronics hardware and software. It assumes a single, central test facility and all test equipment, computers, and displays have been purchased in 1.7.1.
1.7.4	Detector Control System	Develop specifications and requirements for slow control system for Nova DAQ.
1.7.5	Management - R&D Phase	Management tasks and budget for DAQ subproject during the R&D phase.
1.7.6	Operate IPND	Resources required to operate the IPND in the MINOS Service Building.
2.7	Data Acquisition System	This level 2 summary element includes the hardware and software to record the data to archival storage and to control and monitor both the Near and Far Detectors. It includes the fiber, cable, switches, and memory necessary to move and buffer the data, a PC farm for inline filtering, local disk storage, a system for moving data to permanent storage at Fermilab, software, and testing.
2.7.1	DAQ Software	Produce and test software to run on buffering/triggering hardware for archival of selected time frames and required online database.
2.7.2	DAQ Hardware	Design, QA, and install hardware for receiving signals from FEB, buffering and archival, delivery of clock/timing signals.
2.7.3	Integration	Integration testing of DAQ and trigger electronics hardware and software.
2.7.4	Detector Control System	Controls required to receive and archive monitoring data as needed.
2.7.5	Management - Construction Phase	This WBS element includes the tasks required to support and manage WBS 2.7 activities including quality assurance, value management, risk management, monitoring of performance and schedule, preparation of reports and other related activities.

NOVA PROJECT
WBS DICTIONARY

WBS	Activity Description	WBS Definition
1.8	Detector Assembly R&D	Perform R&D work to validate and optimize the mechanical designs and installation procedures for the NOvA Near and Far Detectors. This includes structural engineering calculations of the fully and partially assembled detectors, the mechanical design and prototyping of detector assembly mechanical systems and tooling, and the construction and testing of prototypes of both Near and Far Detectors. This task will select and document the baseline designs that will be used as the basis for the NOvA CDR and TDR.
1.8.1	Plane Assembly Adhesive R&D	The goal of this task is to choose an adhesive that is suitable for bonding extrusion modules together into 31-plane blocks for the far detector. The same adhesive will be used to construct the 7/8-plane segments for the near detector. This task is performed in close coordination with the determination of detector structural requirements (WBS 1.8.2) and design of the adhesive dispenser (under WBS 1.8.6). WBS 1.8.1 involves the specification of adhesive requirements, the development of adhesive test procedures, and the identification and testing of suitable adhesive candidates.
1.8.2	Structural Design and Validation	The goal of this task is to develop and optimize the structural design of the far detector, which is assembled from vertical planes of alternating horizontal and vertical extrusion modules and filled with liquid scintillator. This task involves the Finite Element Analyses (FEAs) of different candidate structures during assembly, before and after filling with liquid scintillator. The analysis will provide mechanical strength requirements for PVC extrusions, the adhesive that bonds them together and the bottom end seals on the vertical extrusion modules that support the weight of the detector. A series of small-scale and large-scale prototype structures will be constructed to check FEA predictions of the behavior of candidate structures. This task will be carried out in close coordination with the choice of adhesive (WBS 1.8.1) and the design of assembly fixtures (WBS 1.8.6). The large-scale prototype structures built under WBS 1.8.8 will provide a final validation of the structural analysis calculations performed under this task.
1.8.3	Liquid Scintillator Filling & Handling R&D	The goal of this task is to develop techniques and semi-automatic equipment for filling the near and far detector extrusion modules with liquid scintillator. This task provides specifications for the far detector liquid scintillator supply system, which is being built by WBS 2.1. It also makes use of the scintillator quality assurance equipment that is provided by WBS 2.2. The required rate of filling modules must be coordinated with both the scintillator production schedule of WBS 2.2 and the detector-filling rate specified by the far detector installation tasks, WBS 1.8.7 and 2.9.4.
1.8.4	Near Detector Assembly R&D	The goal of this task is to develop the procedures and for assembling the near detector. This includes specification of the near detector dimensions so that the components can be moved down the existing shaft and installed in the existing underground tunnel. This task includes the design of rigging equipment to move detector components into position and the moving system that allows it to be moved along the tunnel after it is filled with liquid scintillator. The task also includes the design of an assembly facility and associated procedures and equipment for assembling extrusion modules into 7/8-plane segments that can be moved underground. Finally, this task will design the steel-plate muon-catcher segment of the near detector, along with associated support structures and assembly equipment.
1.8.5	Integration Prototype Near Detector (IPND)	The goal of this task is to design, fabricate and install the Integration prototype Near Detector (IPND). The IPND will be structurally very similar to the Near Detector (ND) itself and it is likely that some components of the IPND will be reused for the ND, including the muon-catcher steel plates and perhaps some or all of the extrusion module segments. For this reason, IPND components will be designed so that they can be moved to the underground tunnel location of the ND. The IPND will be installed and operated at ground level in the MINOS Service Building, where it will be exposed to an off-axis beam of muon and electron neutrinos. It may also be moved to a charged particle test beam for further calibration at a later time. It is likely that the segment assembly facility for the IPND will be reused for the ND. The construction and installation schedule of the IPND will be closely coordinated with the suppliers of extrusion modules (WBS 2.5), readout hardware (WBS 2.6 and 2.7) and liquid scintillator (WBS 2.2). The schedule for construction and operation of the IPND will be coordinated with planning for the ND (WBS 2.8), because some IPND components will be re-used for the ND.
1.8.6	Far Detector Assembly Engineering	The goal of this task is to specify and design the equipment needed to assemble and install the far detector. This includes cranes and other moving equipment required at the far detector site, as well as specialized equipment such as the block raiser and adhesive dispenser. This task will be closely coordinated with far detector installation planning (WBS 1.8.7), far detector prototype construction (WBS 1.8.8), as well as WBS 1.8.1, 1.8.2 and 1.8.3, which specify the adhesive requirements, detector structure, and liquid scintillator filling equipment.

1.8.7	Far Detector Installation Procedures	The goal of this task is to develop far detector installation procedures, schedules and labor requirements. This task is performed in close coordination with other WBS 1.8 far detector R&D tasks and with the Level 2 tasks that provide extrusion modules (WBS 2.5), readout hardware (WBS 2.6 and 2.7) and liquid scintillator (WBS 2.2). It must be very closely coordinated with the design of the far detector building and infrastructure by WBS 2.1. The far detector assembly must be accomplished as rapidly as possible in a cost effective, safe and environmentally responsible manner. This task will develop and evaluate the mechanical assembly quality assurance and safety protocols that will be used at the far detector site. The far detector prototype task, WBS 1.8.8, will provide valuable tests of the procedures, schedules and labor estimates developed under this task.
1.8.8	Far Detector Prototypes	The goal of this task is to test and optimize the procedures and equipment designs developed under other WBS 1.8 far detector tasks, by constructing full-size mechanical prototype structures of extrusion modules. The full-scale block-assembly prototype will test the installation procedures developed under WBS 1.8.7 and will perform time-and-motion studies of these procedures to allow the optimization of the installation schedule and its labor requirements. The full-height structural engineering prototype will provide a final check of structural engineering analyses relating to the mechanical stability of the detector in all stages of construction, before and after it is raised and filled with liquid scintillator. This task will lead to the final optimization of the designs of assembly tooling and materials handling equipment. It will culminate in the assembly, erection and testing of a full-size 31-plane block of the far detector under WBS 2.9.2.4, using the block raiser and other assembly equipment constructed for use at the far detector site.
1.8.9	Management - R&D Phase	Subproject management activities for the Detector Assembly R&D phase
2.8	Near Detector Assembly	This level 2 element provides for site preparation of the region to contain the Near Detector, mechanical assembly and installation of the detector itself, assembly of a liquid scintillator filling system extending from the MINOS service building to underground plus utilization of this system, and finally oversight of the outfitting of the detector to ready it for doing physics. The site preparation consists of the repositioning of considerable MINOS cabling and infrastructure, and the construction, once the repositioning is compete, of a new cavern at the appropriate off axis angle. The constrution of the detector involves the steel and PVC modules of the muon catcher, three blocks recycled from the IPND and three new blocks.
2.8.1	Near Detector Site Preparation	Complete the engineering design, procurement, and fabrication and installation of the utilities and infrastructure required to install and operate the Near Detector in its underground tunnel location. These systems include excavation, lighting, HVAC, electrical power, fire protection, chilled water, and liquid scintillator containment. Also included are technical and ES&H reviews and approvals of equipment and assembly procedures.
2.8.2	Mechanical Construction and Installation	Complete the engineering design, procurement, and fabrication of the Near Detector muon steel segment, the detector support structure, and the systems for moving the detctor subassemblies underground and to different positions along the MINOS access tunnel. Also included are any shipping and moving costs and the final optimization, review, and approval of equipment and assembly procedures.
2.8.3	Liquid Scintillator Filling Equipment	Complete the engineering design, procurement, and fabrication of the Near Detector liquid scintillator supply system, the filling machine, and the plumbing that connects these together and to the detector modules. Secondary containment of the liquid scintillator is included as well as any shipping and moving costs and the final optimization, review, and approval of equipment and assembly procedures.
2.8.4	Installation Coordination	Install readout electronics, cabling, plumbing, filling with liquid scintillator, final component QA tests, detector alignment, the implemetation of safety systems, the review and approval of equipment and installation procedures, and the documentation and intial commissioning of the assembled detector and its moving system.
2.8.5	Management - Construction Phase	This WBS element includes the tasks required to support and manage WBS 2.8 activities including quality assurance, value management, risk management, schedule monitoring, preparation of reports and other related activities.
2.9	Far Detector Assembly	This task provides for the engineering design of the mechanical systems and tooling needed to install the NOvA Far Detector. Fabrication of the necessary tooling, installation and commissioning of the detector in the detector building in northern Minnesota is also included. This task requires close coordination with the WBS 2.1 (far site and buildings), WBS 2.2 (scintillator), WBS 2.5 (PVC modules), and WBS 2.6/2.7 (electronics and DAQ).
2.9.1	Mechanical Systems	Complete the engineering design, procurement and fabrication of the Far Detector mechanical support structures and other block assembly equipment, including the block pivoter, block safety contraint beam, module lifting fixtures, adhesive dispenser, and survey equipment. This task includes final optimization, review and approval of associated equipment and assembly procedures.

2.9.2	Detector Infrastructure	Install infrastructure necessary to support detector construction, including electrical infrastructure for detector assembly and scintillator filling equipment and design and fabrication of the north and south bookends. This also includes engineering design, procurement, and fabrication of the block raiser, the 31-plane block assembly fixtures, the adhesive dispensing system, and the detector alignment systems. It also incluedes any shipping and moving costs and the final optimization, review, and approval of associated equipment and assembly procedures.
2.9.3	Scintillator Filling Equipment	Complete the engineering design, the procurement and fabrication of the Far Detector liquid scintillator transfer and filling equipment, the associated distribution controls, the distribution plumbing that connects the transfer equipment to the filling machines and detector modules and the vapor recovery system.
2.9.4	Block Assembly and Installation	Design and construction of the block pivoter, procurement and installation of the adhesive dispenser, esign and procurement of the block pallets that form the base of each block, procuremetn of the adhesive required for block assembly, and the scintillator expansion tanks required prior to filling the assembled blocks with liquid scintillator. It also includes the assembly and erection of blocks, installation of readout electronics, cabling and plumbing, filling the blocks with liquid scintillator, final component QA tests, detector alignment, the implementation of safety systems, the review and approval of equipment and installation procedures, and the documentation and initial commissioning of the assembled detector.
2.9.5	Management - Construction Phase	This WBS element includes the tasks required to support and manage WBS 2.9 activities including quality assurance, value management, risk management, schedule monitoring, preparation of reports and other related activities.

NOVA PROJECT
WBS DICTIONARY

WBS	Activity Description	WBS Definition
1.9	Project Management - R&D	This level 2 summary element provides for internal project reviews, report preparation, site visits, local supervision, standards preparation, tracking and analysis, schedule preparation tracking and analysis, and change control. It also includes procurement of relevant software and computers, cost of running the project office, and the salaries of non-scientists working on the project.
2.10	Project Management - Construction	This Level 2 summary element consists of reviews, reports, site visits, local supervision, running technical board meetings, standards preparation, tracking and analysis, schedule preparation tracking and analysis, change control. It also includes procurement of relevant software and computers, the cost of running the project office and the salaries of non-scientists working in the project office.

WBS	Activity Description
1	Research and Development
1.0	ANU Planning, Engineering & Design
1.0.1	Recycler Upgrades
1.0.2	Main Injector Upgrades
1.0.3	NuMI Upgrades
1.0.4	Beam Physics
1.0.5	Project Management
1.1	Site and Building
1.1.1	Site Conditions Investigation
1.1.2	Title 1 Preparation
1.1.3	(Retired)
1.1.4	Management - R&D Phase
1.2	Liquid Scintillator R&D
1.2.1	Requirements
1.2.2	Scintillator Composition Studies
1.2.3	Accelerated Aging Studies

1.2.4	Scintillator Production Method Studies
1.2.5	Development of QC Methods
1.2.6	Scintillator Transportation Studies
1.2.7	Blending Investigations
1.2.8	Component Aquisition Investigations
1.2.9	Integration Prototype Detector Scintillator Production
1.2.10	Production Scintillator Specifications
1.2.11	Management - R&D Phase
1.3	Wave-Length-Shifting Fiber R&D
1.3.1	Requirements
1.3.2	Vendor Investigations
1.3.3	WLS Fiber Optimization Studies
1.3.4	Development of QA Methods
1.3.5	Integration Prototype Detector Fiber Production
1.3.6	Production WLS Fiber Specifications
1.3.7	Management - R&D Phase
1.4	PVC Extrusion R&D
1.4.1	Physical Properties Determination and Test Method Development
1.4.2	Raw Materials
1.4.3	Extrusions
1.4.4	Shipping & Handling
1.4.5	Quality Assurance Hardware
1.4.6	Management - R&D Phase

1.5	PVC Module R&D
1.5.1	Requirements
1.5.2	End Seal R&D
1.5.3	Photo Detector Interface R&D
1.5.4	Module Factory R&D
1.5.5	Quality Assurance and Quality Control Methods Development
1.5.6	Module Shipping and Storage R&D
1.5.7	Integration Prototype Detector (IPND) Modules
1.5.8	Initial Production Module Specifications
1.5.9	Initial Factory Tooling Specifications
1.5.10	Management - R&D Phase
1.5.11	Module Shipping and Storage R&D - Part 2
1.6	Electronics R&D
1.6.1	APD Modules
1.6.2	FEB
1.6.3	Power Distribution
1.6.4	Management - R&D Phase
1.6.5	Vertical Slice Tests
1.7	DAQ System R&D
1.7.1	DAQ Software
1.7.2	DAQ Hardware
1.7.3	Integration
1.7.4	Detector Control System
1.7.5	Management - R&D Phase
1.7.6	Operate IPND

1.8	Detector Assembly R&D
1.8.1	Plane Assembly Adhesive R&D
1.8.2	Structural Design and Validation
1.8.3	Liquid Scintillator Filling & Handling R&D
1.8.4	Near Detector Assembly R&D
1.8.5	Integration Prototype Near Detector (IPND)

1.8.6	Far Detector Assembly Engineering
1.8.7	Far Detector Installation Procedures
1.8.8	Far Detector Prototypes
1.8.9	Management - R&D Phase
1.9	Project Management - R&D
2	Construction Project
2.0	ANU Construction
2.0.1	Recycler Upgrades
2.0.1.1	Recycler Ring Modifications
2.0.1.2	Recycler Kicker System

2.0.1.3	Recycler Instrumentation
2.0.2	Main Injector Upgrades
2.0.2.1	MI Modifications
2.0.2.2	MI RF Cavities
2.0.3	NuMI Upgrades
2.0.3.1	NuMI Primary Proton Beam
2.0.3.2	NuMI Target Hall Technical Components
2.0.3.3	NuMI Target Hall Infrastructure
2.0.3.4	NuMI Decay Pipe/Hadron Absorber/Utilities
2.0.4	Project Management
2.1	Site and Building
2.1.1	Site Preparation Package
2.1.2	Far Detector Building
2.1.3	Site and Building Security

2.1.4	Management
2.2	Liquid Scintillator
2.2.1	Mineral Oil
2.2.2	Pseudocumene
2.2.3	Waveshifters and Stadis 425
2.2.4	Blending
2.2.5	Transport
2.2.6	Management - Construction Phase
2.3	Wave-Length-Shifting Fiber
2.3.1	Procurement
2.3.2	Production
2.3.3	Management - Construction Phase
2.4	PVC Extrusions
2.4.1	Procurement
2.4.2	Extrusion Pre-Production
2.4.3	Extrusion Production
2.4.4	Production Quality Assurance and Extrusion Evaluation
2.4.5	Shipping & Handling
2.4.6	Management - Construction Phase

2.5	PVC Modules
2.5.1	End Seals
2.5.2	Optical Connector Production
2.5.3	Module Production
2.5.4	Management - Construction Phase
2.6	Electronics Production
2.6.1	APD Module Production
2.6.2	Readout - FEB
2.6.3	Readout Infrastructure
2.6.4	Management - Construction Phase
2.7	Data Acquisition System
2.7.1	DAQ Software
2.7.2	DAQ Hardware
2.7.3	Integration
2.7.4	Detector Control System
2.7.5	Management - Construction Phase

2.8	Near Detector Assembly
2.8.1	Near Detector Site Preparation
2.8.2	Mechanical Construction and Installation
2.8.3	Liquid Scintillator Filling Equipment
2.8.4	Installation Coordination
2.8.5	Management - Construction Phase
2.9	Far Detector Assembly
2.9.1	Mechanical Systems
2.9.2	Detector Infrastructure
2.9.3	Scintillator Filling Equipment

2.9.4	Block Assembly and Installation
2.9.5	Management - Construction Phase
2.10	Project Management - Construction

WBS Definition
This summary level task is the work for the research and development of the Accelerator and NuMI Upgrades, the Nova Near and Far Detectors, and the Far Detector Hall.
This Level 2 element covers the necessary removal of elements and the overall design and planning and needed for the accelerator and NuMI upgrades.
This summary task for the work to convert the Recycler Ring from an anti-proton storage ring to a proton pre-injector, includes planning for removing anti-proton specific devices in the Recycler, design of new injection and extraction lines, design of new injection, extraction, and abort kickers, design of a new 53 MHz RF system, and engineering to upgrade the instrumentation.
This summary task covers the modifications to low level RF systems and associated machine timing modifications. It also includes planning for and removal of existing magnets and cavities no longer required. It also covers engineering for upgrades to existing LCW and RF cooling systems. Also included is the engineering and design for two extra MI RF stations.
This summary task covers the design and planning for modifications to NuMI Beamline to support 700kW NOvA operation in the medium energy neutrino beam configuration. It includes the primary beam upgrades to support a higher beam cycle time, upgrades to the cooling systems throughout the beamline for the increases power, and electrical infrastructure to support the additional power needs. Also included is the planning, engineering and design for a medium energy target, baffle and carrier and an upgraded hadron monitor. Planning for how the horn 2 will be moved to the medium energy position and the design of the stripline to connect to it in the new position are included.
This summary task is to evaluate the efficacy of Proton Plan upgrades as applied to the ANU project, to perform preparative beam physics measurements, calculations, and simulations of the eventual ANU operation, and to establish and maintain a method of extrapolation to estimate future ANU proton production.
This WBS details the management and administrative resources required by ANU during FY07. It includes labor for PM, deputy PM, L3, L4 mgrs, project engineers, ESH professional.
This level 2 element covers the design, planning, and value engineering for the Far Detector Hall as well as the site evaluation and environmental assessment.
Site Conditions Investigation consists of the tasks required to provide a comprehensive understanding of the site conditions.
Document Development continues the development of the conceptual design and includes selecting and integrating building systems and materials, developing installation details focused on constructability, and describing the details with technically precise drawings and specifications.
Logistics is the process of planning, implementing and controlling the support functions of the project site during the construction phase including site utilities, maintenance, safeguards and security. The R&D Phase will investigate the requirements for the site logistics
Management for the R&D phase includes oversight of associated tasks as well as studies and investigations to verify choices or options
This level 2 summary element coverst he developmetn and documentation of the specifications for the liquid scintillator required for both the enar and far detectors. This includes the studies, simulations, and measurements required to define these elements.
Requirements document detailing experiment requirements on the liquid scintillator
Studies of light yield as a function of pseudocumene content;studies of light yield as a function of fluor (PPO, POPOP, bis-MSB) content; simulations of requirements on mineral oil attenuation length; measurements of mineral oil attenuation length; studies of light yield in an a-cell; studies of light yield in a test extrusion cells with scintillator mixed with mineral oil of varying attenuation lengths
Studies of the effect of pseudocumene content on fiber; studies of the effect of pseudocumene content on PVC; studies of the effect of pseudocumene content on glue joints

Development of plan for scintillator production at Fermilab: (a) production of complete scintillator with premixed fluors (Eljen or Bicron) + mineral oil - mixing fluor mix with mineral oil, (b) production of complete scintillator from mineral oil, psuedocumene, & waveshifters - mixing waveshifters and pseudocumene - mixing fluor mix with mineral oil
Develop reliable, accurate QC testing procedures for mineral oil arriving at mixing facility; develop reliable, accurate QC testing procedures for pseudocumene arriving at mixing facility; develop reliable, accurate QC testing procedures for testing mixed scintillator light yield at the mixing facility; develop reliable, accurate QC testing procedures for testing mixed scintillator light yield at the far detector site
Delivering: mineral oil to Fermilab production facility by truck or rail delivering: (a) premix from Eljen or Bicron to the Fermilab production facility, or (b) fluors by commercial shipper and pseudocumene by truck or rail to the Fermilab production facility delivering: mixed scintillator 'just-in-time' to (a) near detector by truck , (b) far detector by rail or truck if optimum procedure is to deliver scintillator by rail to far detector, delivery of mixed scintillator from rail head to experiment specifications: (a) for heated tankers (truck or rail) for mineral oil and mixed scintillator, (b) for heated ISO tankers
Bicron (Saint-Gobain) for mixed scintillator -- can they produce enough materail to our specs? Q/C? Eljen or Bicron for premix -- can they make it to our specs? How will they handle Q/C on quantities they have probably not dealt with Mineral oil for premix or homebrew -- Penrico, Sonneborne, ... -- RFP already released Pseudocumene for homebrew -- RFP in draft form PPO, POPOP, bis-MSB form Curtisslab or European vendor -- RFP to be released
Investigate the options available for acquiring the various components required to blend liquid scintillator.
Delivery of scintillator components to Fermilab production facility production of mixed scintillator - fluors + mineral oil, or - waveshifters, pseudocumene, mineral oil delivery of mixed scintillator to the integration prototype near detector
Technical specification document for procurement of production quantities of liquid scintillator
Subproject management activties for the liquid scintillator R&D phase
This level 2 summary element covers the development and documentation of the requirements for procurement, QA, storage, and shipping of the wavelength shifting fiber.
Develop a document detailing the specifications for the wavelength shifting fiber.
Develop, assess, and verify the ability of vendors to produce and QC wavelength shifting fiber to meet our specifications.
Studies of wavelength shifting fiber to optimize the performance for our specific application.
Develop methods and procedures for QA testing of the wavelength shifting fiber.
Deliver and QA the fiber for the integration prototype near detector.
Produce the technical specification documents for procurement of production quantities of wavelength shifting fiber.
Subproject management activities for the WLS Fiber R&D phase
This level 2 summary element includes sutdies of various PVC materials and their properties, production of prototype extrusions, as well as the development and documentation of QA and shipping plans for the PVC extrusions.
Measure optical and mechanical properties of extrusions and compare to NOvA specifications.
Select PVC blend and capstocking blend for prototype extrusion production.
Identify extruders capable of producing NOvA (full or half-width) profiles. Select an extruder to produce prototype profiles. Develop methods for assuring the quality of extruded products, specifically the reflectivity and geometrical dimensions. Develop a shipping and handling plan for delivery of extrusions.
Develop shipping and handling plan for delivery of extrusions.
Modify prototype QA hardware to be used for QA of preproduction extrusions.
Subproject management activities for the PVC extrusion R&D phase

This level 2 summary element provides for develpoment and documentation of the procedures for assembly of the PVC modules and the design of the fiber manifolds, end seals, and the various machines and fixtures necessary for module construction. Development of QA and shipping plans is also included.
Develop requirements documents for module assembly, manifolds, and end seals. QA requirements for the completed modules are also included.
Design and develop the manifolds and end seals as well as specification of QA procedures.
Design and develop photodetector interface as well as specification of QA procedures.
Develop assembly methods for the PVC modules as well as design of machines, tooling, and moving fixtures.
Develop a QA plan for PVC module production. Consturction of required testing equipment is also included.
Develop plan for shipping and handling of extrusion modules between the module factory and the Detector sites and for managing the equipment necessary for shipping and handling.
Produce the PVC modules for the integration prototype near detector.
Develop initial production module specifications.
Develop initial factory tooling specifications.
Management tasks and budget for PVC module subproject during the R&D phase
Develop plan for shipping and handling of extrusion modules between the module factory and the Detector sites and for managing the equipment necessary for shipping and handling.
This level 2 summary element includes the design, development, and testing of the front end electronics and infrastructure.
Development and procurement of prototype APD chips, APD carrier boards, TE coolers, optical connectors and the associated hardware that comprise the APD modules. Development of specifications for fiber alignment, power consumption, cooling, and QA are also included. APD modules for the Integration Prototype Near Detector are included here.
Design the front-end boards as well develop the testing and installation procedures. Front-end boards for the Integration Prototype Near Detector are included here.
Design and specify the low voltage, high voltage, cooling, and power distribution fo rthe NOvA electronics. Power distribution for the Integration Prototype Near Detector is included here.
Management tasks and budget for Electronics subproject during the R&D phase.
Create small-scale test facility for evaluating various configurations of prototype PVC extrusions, liquid scintillator, and WLS fiber using cosmic ray muons, APDs, and prototype versions of the front-end board.
This summary level element incldues the development of specifications and design of the hardware and software necessary to acquire and record data to archival storage and to control and monitor both the Near and Far Detectors.
Design and develop specifications for software to run on buffering/triggering hardware for archival of selected time frames and required online database
Design and develop specifications for hardware for receiving signals from FEB, buffering and archival, delivery of clock/timing signals
Integration testing of DAQ and trigger electronics hardware and software. It assumes a single, central test facility and all test equipment, computers, and displays have been purchased in 1.7.1.
Develop specifications and requirements for slow control system for Nova DAQ.
Management tasks and budget for DAQ subproject during the R&D phase.
Resources required to operate the IPND in the MINOS Service Building.

Perform R&D work to validate and optimize the mechanical designs and installation procedures for the NOvA Near and Far Detectors. This includes structural engineering calculations of the fully and partially assembled detectors, the mechanical design and prototyping of detector assembly mechanical systems and tooling, and the construction and testing of prototypes of both Near and Far Detectors. This task will select and document the baseline designs that will be used as the basis for the NOvA CDR and TDR.
The goal of this task is to choose an adhesive that is suitable for bonding extrusion modules together into 31-plane blocks for the far detector. The same adhesive will be used to construct the 7/8-plane segments for the near detector. This task is performed in close coordination with the determination of detector structural requirements (WBS 1.8.2) and design of the adhesive dispenser (under WBS 1.8.6). WBS 1.8.1 involves the specification of adhesive requirements, the development of adhesive test procedures, and the identification and testing of suitable adhesive candidates.
The goal of this task is to develop and optimize the structural design of the far detector, which is assembled from vertical planes of alternating horizontal and vertical extrusion modules and filled with liquid scintillator. This task involves the Finite Element Analyses (FEAs) of different candidate structures during assembly, before and after filling with liquid scintillator. The analysis will provide mechanical strength requirements for PVC extrusions, the adhesive that bonds them together and the bottom end seals on the vertical extrusion modules that support the weight of the detector. A series of small-scale and large-scale prototype structures will be constructed to check FEA predictions of the behavior of candidate structures. This task will be carried out in close coordination with the choice of adhesive (WBS 1.8.1) and the design of assembly fixtures (WBS 1.8.6). The large-scale prototype structures built under WBS 1.8.8 will provide a final validation of the structural analysis calculations performed under this task.
The goal of this task is to develop techniques and semi-automatic equipment for filling the near and far detector extrusion modules with liquid scintillator. This task provides specifications for the far detector liquid scintillator supply system, which is being built by WBS 2.1. It also makes use of the scintillator quality assurance equipment that is provided by WBS 2.2. The required rate of filling modules must be coordinated with both the scintillator production schedule of WBS 2.2 and the detector-filling rate specified by the far detector installation tasks, WBS 1.8.7 and 2.9.4.
The goal of this task is to develop the procedures and for assembling the near detector. This includes specification of the near detector dimensions so that the components can be moved down the existing shaft and installed in the existing underground tunnel. This task includes the design of rigging equipment to move detector components into position and the moving system that allows it to be moved along the tunnel after it is filled with liquid scintillator. The task also includes the design of an assembly facility and associated procedures and equipment for assembling extrusion modules into 7/8-plane segments that can be moved underground. Finally, this task will design the steel-plate muon-catcher segment of the near detector, along with associated support structures and assembly equipment.
The goal of this task is to design, fabricate and install the Integration prototype Near Detector (IPND). The IPND will be structurally very similar to the Near Detector (ND) itself and it is likely that some components of the IPND will be reused for the ND, including the muon-catcher steel plates and perhaps some or all of the extrusion module segments. For this reason, IPND components will be designed so that they can be moved to the underground tunnel location of the ND. The IPND will be installed and operated at ground level in the MINOS Service Building, where it will be exposed to an off-axis beam of muon and electron neutrinos. It may also be moved to a charged particle test beam for further calibration at a later time. It is likely that the segment assembly facility for the IPND will be reused for the ND. The construction and installation schedule of the IPND will be closely coordinated with the suppliers of extrusion modules (WBS 2.5), readout hardware (WBS 2.6 and 2.7) and liquid scintillator (WBS 2.2). The schedule for construction and operation of the IPND will be coordinated with planning for the ND (WBS 2.8), because some IPND components will be re-

The goal of this task is to specify and design the equipment needed to assemble and install the far detector. This includes cranes and other moving equipment required at the far detector site, as well as specialized equipment such as the block raiser and adhesive dispenser. This task will be closely coordinated with far detector installation planning (WBS 1.8.7), far detector prototype construction (WBS 1.8.8), as well as WBS 1.8.1, 1.8.2 and 1.8.3, which specify the adhesive requirements, detector structure, and liquid scintillator filling equipment.
The goal of this task is to develop far detector installation procedures, schedules and labor requirements. This task is performed in close coordination with other WBS 1.8 far detector R&D tasks and with the Level 2 tasks that provide extrusion modules (WBS 2.5), readout hardware (WBS 2.6 and 2.7) and liquid scintillator (WBS 2.2). It must be very closely coordinated with the design of the far detector building and infrastructure by WBS 2.1. The far detector assembly must be accomplished as rapidly as possible in a cost effective, safe and environmentally responsible manner. This task will develop and evaluate the mechanical assembly quality assurance and safety protocols that will be used at the far detector site. The far detector prototype task, WBS 1.8.8, will provide valuable tests of the procedures, schedules and labor estimates developed under this task.
The goal of this task is to test and optimize the procedures and equipment designs developed under other WBS 1.8 far detector tasks, by constructing full-size mechanical prototype structures of extrusion modules. The full-scale block-assembly prototype will test the installation procedures developed under WBS 1.8.7 and will perform time-and-motion studies of these procedures to allow the optimization of the installation schedule and its labor requirements. The full-height structural engineering prototype will provide a final check of structural engineering analyses relating to the mechanical stability of the detector in all stages of construction, before and after it is raised and filled with liquid scintillator. This task will lead to the final optimization of the designs of assembly tooling and materials handling equipment. It will culminate in the assembly, erection and testing of a full-size 31-plane block of the far detector under WBS 2.9.2.4, using the block raiser and other assembly equipment constructed for use at the far detector site.
Subproject management activities for the Detector Assembly R&D phase
This level 2 summary element provides for internal project reviews, report preparation, site visits, local supervision, standards preparation, tracking and analysis, schedule preparation tracking and analysis, and change control. It also includes procurement of relevant software and computers, cost of running the project office, and the salaries of non-scientists working on the project.
WBS 2.0 is for the final design and construction of the NOvA Near and Far Detectors and the Far Detector Hall.
This level 2 element includes the procurement, QA, construction, and installation of components necessary for accelerator improvements in the Main Injector and Recycler, as well as for upgrades to the beamline and target hall at the NuMI Facility.
This summary task for the work to convert the Recycler Ring from an anti-proton storage ring to a proton pre-injector, includes refurbishment of existing magnets, procurement and fabrication of new magnets, installation of injection, extraction, and RR-30 SS beamlines, procurement, fabrication, and installation of the new 53 MHz RF system, and procurement and fabrication of instrumentation upgrades.
This summary task covers procurement and fabrication for new and refurbishing of existing magnets for the Injection, Extraction, and RR-30 SS beamlines, as well as installation of the beamlines. It also includes procurement, fabrication and installation for the new 53 Mhz RF system. It also covers modifications to existing cooling systems.
This summary task covers procurement, fabrication, and installation for the five new kicker systems: RR Injection, Injection Gap Clearing, RR Extraction to MI, MI Injection, and RR Abort. This includes magnets, power supplies, and Fluorinert cooling systems for each of the 5 systems.

This summary task covers the procurement, testing, and installation of upgrades to the existing Recycler BPM system, beam intensity monitors, and damper systems.
This summary task covers the procurement and installation for upgrades to the existing vertical quad bus of MI. It also includes communication infrastructure for the 2 new service buildings. Also included is the procurement, fabrication, and installation of the 2 new RF stations, and the modifications to associated cooling systems.
This summary task includes the procurement and installation of new transformer and modifications for MI vertical quad bus. It also covers procurement and installation of communications infrastructure for the 2 new service buildings at MI14 and MI39.
This summary task covers procurement, fabrication, and installation for the 2 new MI RF stations.
This summary task covers the procurement, fabrication and installation of the modifications to the NuMI Beamline to support 700kW NOvA operation in the medium energy neutrino beam configuration. It includes the primary beam upgrades to support a higher beam cycle time, upgrades to the cooling systems throughout the beamline for the increases power, and electrical infrastructure to support the additional power needs. Also included is the medium energy target, baffle and carrier and an upgraded hadron monitor. Procurement, fabrication and installation of operations equipment in support of moving horn 2 and procurement, fabrication and assembly of the stripline, stripline block and chase temperature monitoring equipment are included also. Installation of the hadron monitor and target/carrier/baffle are included.
This summary task covers the procurement, engineering and technician efforts needed to upgrade the NuMI kicker power supply for increased pulsing repetition rate, to upgrade the 6 NuMI major dipole supplies, and to upgrade the NuMI primary bema profile monitors. It also includes the effort to replace the NuMI quads with the more robust, recovered quads from the A150 line and their power supplies.
This summary task includes purchasing of a medium energy target and baffle from IHEP, purchase and construction of a target carrier and the assembly of all three of these pieces into a single unit ready which is then installed. This task also includes the purchasing of a hadron monitor from University of Texas, Austin and replacing the existing one in the tunnel.
This summary task covers the procurement, fabrication, and installation of operations equipment in the target hall for the NovA upgrades. It also includes procurement, fabrication, assembly and installation of the stripline extension and shielding blocks needed to support the movement of horn 2 to the medium energy location. Also included procurement, fabrication, installation, testing and troubleshooting of target chase cooling equipment and temperature monitoring equipment for the chase. Finally, it includes procurement, fabrication and assembly of new Horn 1 stripline cooling components. Installation of horn 1 and module and horn 2 and module are not on project, but operations tasks.
This task includes the procurement, installation, and start-up for all cooling system modifications for the NuMI cooling systems (RAW and non-RAW) for NOvA operation. It also includes the procurement, installation, and testing of Electrical Infrastructure equipment related to all RAW and Non-RAW Cooling System Modifications.
This WBS details the management and administrative resources required by ANU during FY08-FY12. It includes administrative costs such as travel, computers, training, labor for reviews. It includes labor for PM, deputy PM, L3, L4 mgrs, project engineers, ESH professional.
This level 2 summary element covers the design and construction of the Site Preparation Package and the Far Detector Building
Design and construction of the access road and site preparation work; perform wetlands mitigation in preparation for construction of the Far Detector Building.
Design, construction, and outfitting of the Far Detector Building in northern Minnesota. The building includes the detector enclosure, assembly area, and service building, as well as utilities and safety systems.
Design, procure, and install security systems for the Far Detector site and building.

Support and management of WBS 2.1 activities includign quality assurance, value engineering, risk management, ES&H, monitoring of vendor performance and schedule, preparation of reports, and related activities.
This level 2 summary element covers the procurement, production, QA and shipping of the 5.7 million gallons of liquid scintillator required by the project for both the Near and Far Detectors.
Vendor selection, procurement, transport, and QA of mineral oil required for the liquid scintillator.
Vendor selection, procurement, transport, and QA of pseudocumene required for the liquid scintillator.
Vendor selection, procurement, transport, and QA of waveshifters required for the liquid scintillator as well as for procurement of the anti-static agent Stadis 425.
Select a vendor to blend the liquid scintillator, including blending and QA of the fluor concentrate, blending of the fluor concentrate with the mineral oil, and QA of the final scintillator blend.
Provide truck transport of the blended liquid scintillator from the blending facility to the Near and Far Detector sites.
This WBS includes the tasks required to support and manage WBS 2.2 activities including quality assurance, value management, risk management, monitoring of vendor performance and schedule, preparation of reports and other related activities.
This level 2 summary element covers the procurement, QA and shipping of the 22,000 km of wavelength shifting fiber required by the project.
This WBS provides for producing a list of acceptable vendors after reviewing vendor R&D performance, preparation of RFPs, evaluation of vendor proposals and selection of vendors.
This WBS provides for production of fiber QA testing equipment as well as the development of procedures, documentation and reporting requirements. Delivery of fiber spools to the module factories on a schedule consistent with factory schedules and available storage must also be organized and managed.
This WBS includes the tasks required to support and manage WBS 2.3 activities including quality assurance, value management, risk management, monitoring of vendor performance and schedule, preparation of reports and other related activities.
This level 2 summary element covers the procurement, QA and shipping of the 7000 tons of PVC extrusions required by the project.
This WBS element includes developing a list of vendors capable of producing the NOvA PVC compound and extruders capable of producing the NOvA profiles. Preparation of RFPs, evaluation of vendor proposals and selection of vendors is also included.
This WBS element includes the fabrication of dies, tooling and other hardware needed for the pre-production and production. Pre-production extrusions will be evaluated for adherence to mechanical tolerance, mechanical strength and reflectivity. Quality assurance methods for use in production and handiling procedures will be finalized. Pre-production extrusions will be provided to module assembly factories.
This WBS element provides for supervision and quality assurance monitoring of PVC extrusions.
Procure and set up hardware for performing QA on the PVC extrusions as well as the necessary manpower.
This WBS provides for the development and execution of a shipping and handling plan for delivering extrusions to module factories, for supervising trucking schedules and for managing the equipment necessary for shipping and handling.
This WBS includes the tasks required to support and manage WBS 2.4 activities including quality assurance, value management, risk management, monitoring of vendor performance and schedule, preparation of reports and other related activities.

This level 2 summary element provides for construction and QA of the ~20,000 Far Detector PVC modules and ~400 Near Detector PVC Modules at the module factories and shipping of the completed and tested modules to their respective detector sites.
Produce the fiber manifolds that cover and seal the readout end of a PVC module and route the WLS fibers to the photodetector interface, and produce the bottom plates that seal the other end of the PVC modules.
Final design, procure, and QA the hardware necessary to connect the WLS fibers from the PVC modules to the APD modules.
Set up and operate the module factory where sets of 16-cell PVC extrusions are glued into 32-cell objects, WLS fibers are inserted into each cell, the end seals are blued to the ends of the extrusions, and the WLS fibers are potted into the optical connector. QA of the completed modules as well as the procurement and construction of various machines necessary to assemble and test the modules is also included, along with transport of the completed modules to the Near and Far Detector sites.
This WBS element includes the tasks required to support and manage WBS 2.5 activities including quality assurance, value management, risk management, monitoring of factory performance and schedule, preparation of reports and other related activities.
This level 2 summary element includes procurement of the Avalanche Photo Diode (APD) optical sensors, the thermo-electric (TE) coolers for cooling the APDs, the custom ASIC that amplifies and mutiplexes the APD signals, the ADC that digitizes the signals, and the FPGAs that zero suppress and time-stamps the data. The low-voltage system for the TE coolers and the front-end electornics, the high voltage ssytem for the APDs, and a cooling system to remove the heat from the TE coolers are included, as well as system design, board layout, and assembly and component testing.
Procurement and QA of the APD chips, the APD carrier boards, the TE coolers, and the APD housing hardware. This task includes managing the flow of components for assembly and development and execution of the QA plan.
Delivery of the specified system to receive signals from the APD modules, digitize them, and deliver them to the DAQ system. This task includes managing the flow of components for assembly and development and execution of the QA plan.
Design, production, and installation of the infrastructure required to deliver power and cooling to operate the FEBs and APDs.
This WBS element includes the tasks required to support and manage WBS 2.6 activities including quality assurance, value management, risk management, monitoring of performance and schedule, preparation of reports and other related activities.
This level 2 summary element includes the hardware and software to record the data to archival storage and to control and monitor both the Near and Far Detectors. It includes the fiber, cable, switches, and memory necessary to move and buffer the data, a PC farm for inline filtering, local disk storage, a system for moving data to permanent storage at Fermilab, software, and testing.
Produce and test software to run on buffering/triggering hardware for archival of selected time frames and required online database.
Design, QA, and install hardware for receiving signals from FEB, buffering and archival, delivery of clock/timing signals.
Integration testing of DAQ and trigger electronics hardware and software.
Controls required to receive and archive monitoring data as needed.
This WBS element includes the tasks required to support and manage WBS 2.7 activities including quality assurance, value management, risk management, monitoring of performance and schedule, preparation of reports and other related activities.

This level 2 element provides for site preparation of the region to contain the Near Detector, mechanical assembly and installation of the detector itself, assembly of a liquid scintillator filling system extending from the MINOS service building to underground plus utilization of this system, and finally oversight of the outfitting of the detector to ready it for doing physics. The site preparation consists of the repositioning of considerable MINOS cabling and infrastructure, and the construction, once the repositioning is compete, of a new cavern at the appropriate off axis angle. The constrution of the detector involves the steel and PVC modules of the muon catcher, three blocks recycled from the IPND and three new blocks.
Complete the engineering design, procurement, and fabrication and installation of the utilities and infrastructure required to install and operate the Near Detector in its underground tunnel location. These systems include excavation, lighting, HVAC, electrical power, fire protection, chilled water, and liquid scintillator containment. Also included are technical and ES&H reviews and approvals of equipment and assembly procedures.
Complete the engineering design, procurement, and fabrication of the Near Detector muon steel segment, the detector support structure, and the systems for moving the detctor subassemblies underground and to different positions along the MINOS access tunnel. Also included are any shipping and moving costs and the final optimization, review, and approval of equipment and assembly procedures.
Complete the engineering design, procurement, and fabrication of the Near Detector liquid scintillator supply system, the filling machine, and the plumbing that connects these together and to the detector modules. Secondary containment of the liquid scintillator is included as well as any shipping and moving costs and the final optimization, review, and approval of equipment and assembly procedures.
Install readout electronics, cabling, plumbing, filling with liquid scintillator, final component QA tests, detector alignment, the implemetation of safety systems, the review and approval of equipment and installation procedures, and the documentation and intial commissioning of the assembled detector and its moving system.
This WBS element includes the tasks required to support and manage WBS 2.8 activities including quality assurance, value management, risk management, schedule monitoring, preparation of reports and other related activities.
This task provides for the engineering design of the mechanical systems and tooling needed to install the NOvA Far Detector. Fabrication of the necessary tooling, installation and commissioning of the detector in the detector building in northern Minnesota is also included. This task requires close coordination with the WBS 2.1 (far site and buildings), WBS 2.2 (scintillator), WBS 2.5 (PVC modules), and WBS 2.6/2.7 (electronics and DAQ).
Complete the engineering design, procurement and fabrication of the Far Detector mechanical support structures and other block assembly equipment, including the block pivoter, block safety contraint beam, module lifting fixtures, adhesive dispenser, and survey equipment. This task includes final optimization, review and approval of associated equipment and assembly procedures.
Install infrastructure necessary to support detector construction, including electrical infrastructure for detector assembly and scintillator filling equipment and design and fabrication of the north and south bookends. This also includes engineering design, procurement, and fabrication of the block raiser, the 31-plane block assembly fixtures, the adhesive dispensing system, and the detector alignment systems. It also incluedes any shipping and moving costs and the final optimization, review, and approval of associated equipment and assembly procedures.
Complete the engineering design, the procurement and fabrication of the Far Detector liquid scintillator transfer and filling equipment, the associated distribution controls, the distribution plumbing that connects the transfer equipment to the filling machines and detector modules and the vapor recovery system.

Design and construction of the block pivoter, procurement and installation of the adhesive dispenser, esign and procurement of the block pallets that form the base of each block, procuremetn of the adhesive required for block assembly, and the scintillator expansion tanks required prior to filling the assembled blocks with liquid scintillator. It also includes the assembly and erection of blocks, installation of readout electronics, cabling and plumbing, filling the blocks with liquid scintillator, final component QA tests, detector alignment, the implementation of safety systems, the review and approval of equipment and installation procedures, and the documentation and initial commissioning of the assembled detector.
This WBS element includes the tasks required to support and manage WBS 2.9 activities including quality assurance, value management, risk management, schedule monitoring, preparation of reports and other related activities.
This Level 2 summary element consists of reviews, reports, site visits, local supervision, running technical board meetings, standards preparation, tracking and analysis, schedule preparation tracking and analysis, change control. It also includes procurement of relevant software and computers, the cost of running the project office and the salaries of non-scientists working in the project office.